Editorial

Guest Editors for this Special Issue

Dr Mohammed Mabrook, School of Electronic Engineering, Bangor University, UK.

Dr Dagou Zeze, School of Engineering & Computer Sciences, Durham University, UK.

Graphene Electronics

Graphene, a two-dimensional hexagonal arrangement of carbon atoms (honeycomb) is attracting significant interest both in academic research and industry. The 2010 Physics Nobel Prize was awarded to Andre Geim and Konstantin Novoselov for their contribution to bring graphene into mainstream research, and it was such a significant stepping stone that it initiated the current trend for graphene to revolutionize technology and to be recognized as a research priority. The Institution of Engineering and Technology is celebrating this significantly unique British achievement in science through a dedicated publication of this special issue of *IET Circuits, Devices & Systems*. This issue contains nine especially invited research articles from leading authorities in the field covering a wide range of topics from latest growth and fabrication techniques to evaluation of fundamental physical properties with an emphasis on their potential applications in advanced electronic devices. The purpose is dissemination of information to the Engineering community particularly in Britain to be involved in exploitation of this novel material for varied engineering applications.

Yan *et al*., Department of Electrical Engineering University of California, Riverside, USA, in collaboration with Moldova State University, Moldova, reported a review on thermal properties of graphene and multilayer graphene, and the possible applications in heat spreaders for thermal management of electronic and optoelectronic devices. The first part of the review focused on the design of graphene heat spreaders based on modelling results, followed by experimental demonstration of graphene heat spreaders used in high-power transistors.

Using structural models, Li and Drabold of Ohio University, USA, explore the impact of topological disorder on the electron localization of amorphous graphene. This theoretical research indicates that electronic states around Fermi level are highly localized around odd-membered rings of amorphous graphene. These observations provide important information for the fabrication of electronic devices based on amorphous graphene.

In the next article, Chakraborty from the University of Manitoba, Canada, and Apalkov from Georgia State University, USA, present an overview of the theoretical understanding of Hofstadter butterflies in monolayer and bilayer graphene. The discovery of the fractal butterfly in graphene found in this research contribution has opened up new directions of research to gain further insight in materials science and fundamental investigation of two-dimensional electrons.

Marconcini and Macucci of Università di Pisa, Italy, presented a theoretical method to study the effect of the voltages applied to a number of bias gates on the potential in a graphene sheet. This method enables a quick evaluation of the transport characteristics of the graphene devices as a function of the applied gate voltages. The results are especially useful in the design and optimization phase, where a short turnaround time is needed for simulations run to understand the effect of changes in the device parameters.

Deposition of graphene on flexible substrates with low sheet resistance, without changing their optical properties is the main problem in commercial adoption of graphene. Kang and his team from the University of Cambridge, UK, in collaboration with Kyung Hee University, Korea, developed a uniform, low-cost and reproducible deposition technique. The novel technique based on chemical vapour deposition (CVD) of doped graphene showed increasing promise for highly transparent and highly conductive flexible electronics which may have applications in OLED displays and next-generation photovoltaic devices.

The radio-frequency (RF) transport electromagnetic properties of CVD graphene on Si/SiO_2 substrate over the DC to 110 MHz frequency range were studied by Awan *et al*. The intrinsic properties of CVD graphene is extracted accurately up to 110 MHz using a precision four terminal-pair (4TP) impedance analyser. These results represent remarkable technological advances in future applications of graphene in electronic devices. Graphene devices in the 4TP configuration could offer potential applications in RF electronics, AC quantum Hall effect metrology and sensors (biological, chemical and physical).

An academia – industry collaboration between the Indian Institute of Science, India, Toyohashi University of Technology, Japan and Tokyo Electron Ltd, Japan, led to a detailed investigation of the flicker noise in graphene films obtained from CVD and chemical reduction of graphene oxide, reported by Kochat co-workers. For polycrystalline graphene films grown by CVD, the grain boundaries and other structural defects were found to act as the major source of noise due to the trapping-detrapping of charge carriers at these defect sites. The link between grain boundaries and noise is useful information for future graphene-based sensors.

Sharon *et al* from the N. Shankaran Nair Research Centre for Nanotechnology & Bionanotechnology, India, reported novel and simple techniques to convert polypropylene (PP) to two-dimensional (2-D) graphene, one-dimensional (1-D) carbon nanotubes and Zero-dimensional (0-D) carbon dots. The study of the electrical and mechanical properties of C-dots may lead to their exploitation as point connectors between circuits.

Alaabdlqader *et al* of Bangor University, UK, have reported the use of thin film graphene oxide as the floating gate in organic thin film memory transistors (OTFMTs). The proposed memory structure produced large hysteresis in the output and transfer characteristics (memory window). They demonstrated clearly that graphene oxide can be used as a reliable candidate in low cost organic electronics as the storage element in organic memory devices. The outcome of this research underlines the great potential for the development of new organic electronic circuits working at low operating voltages.

In brief, the research highlights above are of notable contribution and provide an excellent insight into the latest findings in graphene research, but also make a direct correlation between fundamental research and their applications into novel electronic devices. We are grateful to the Editorial Board for their support for this special issue.